Investigating Alternative Irrigation Strategies

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Introduction

Rising human populations and climate change are putting increasing demands on our already-limited freshwater sources. In response to these concerns, homeowners and municipalities have been encouraged to replace turfgrass – a plant with relatively high irrigation needs – with drought-tolerant plants that do not require frequent irrigation. However, the many benefits of turf-type grasses (erosion control, surfaces for recreation, carbon sequestration, cooling-effects, etc.) have proven it to be irreplaceable in certain settings. Because of these increasing concerns associated with water-use in turfgrass management, the exploration for alternative irrigation strategies and/or sources is necessary. This report describes a set of three field studies designed to investigate optimum irrigation rates and frequencies, rainwater harvesting and greywater irrigation.

Experiment 1: Optimizing Irrigation Rates and Frequencies

In times of drought, outdoor water-use restrictions are most often focused on landscape water use, and implemented in terms of the number of days per week for which watering is allowed. This method, although effective at reducing water use, neglects to consider ideal irrigation frequency for maintaining the health of specific plant species.

Landscapes heavy in low-growing, shallow-rooting groundcovers, such as turfgrass, require more frequent irrigation than landscapes full of woody, deep-rooting plants; thus, plant-specific irrigation requirements should be considered when establishing guidelines for water-use restrictions.

While modern irrigation systems can be incredibly efficient, there still exist many homeowners and property managers with advanced systems whom are guilty of over-irrigating, largely due to the inefficient use of timers. Timers are often unaltered following the installation of optimal-efficiency sprinklers, resulting in little, if any, water savings, and those based on summer irrigation requirements will inherently over-water in the spring and fall.

Claims have been made that deep-and-infrequent irrigation practices will deepen the root zone of turfgrass plants and improve drought tolerance. However, the densest stands of grass are most often found on golf courses where irrigation is applied daily. Region-specific field studies should be conducted to identify proper irrigation techniques to promote acceptable turfgrass quality during periods of drought, while using as little water as possible.

The goal of this study was to identify the optimal irrigation rate and frequency for perennial ryegrass management in the Willamette Valley. The intent/purpose was to determine minimal watering rates that still provide acceptable turfgrass quality throughout the dry summer months experienced in the cool-humid Willamette Valley.

This study applied irrigation – ranging from 5.1 to 10.1 cm per month; or 0.5 to 1.0 inch per week) – at five frequencies (2, 4, 8, and 16 applications per month) to lawn-height

(5.1 cm) perennial ryegrass (Lolium perenne) in the Willamette Valley of Oregon, in an effort to determine minimal watering rates that will still provide acceptable turfgrass quality throughout the summer months. A two-year field trial was initiated in July 2016 and concluded in September 2017 on native soil at the Oak Creek Center for Urban Horticulture, Corvallis, OR. Experimental design was a 2 by 4 by 5 factorial in a randomized complete block design with four replications. Factors included year, irrigation intensity, and irrigation frequency. Irrigation was applied as the schedule prescribed from July through September of 2016, and again from July to September of 2017.

The highest irrigation frequency (16 applications mo-1) consistently produced the greatest turf color, density, percent green cover, and soil moisture throughout the study period in both years (Figure 1). The lack of root-zone storage amongst perennial ryegrass cultivars (i.e. no rhizomes and a relatively shallow rooting depth), combined with the severity of summer drought conditions in the region (sometimes four consecutive months), as well as the relatively low mowing height used in this study (which produced a shallow root zone and decreased overall plant mass), were all contributing factors to the results of this study.

Over two years, it was shown that acceptable-quality turfgrass was provided through applying 8.9 cm mo-1 (Figure 2). This was achieved through light-and-frequent irrigation applications (at least twice per week – with four being better than two). As these findings suggest, recommendations for the Willamette Valley should incorporate higher frequency of applications, along with the caveat that the “inch per week” recommendation is sufficient for peak water demand, but, in the name of water conservation, schedules could (and should) be reduced in the early and late summer when ET rates are less.

While this study was designed to determine optimal irrigation rate and frequency, major concerns still exist regarding irrigation distribution non-uniformity and improper use of timers – with irrigators too-often resorting to bumping up their application rates to account for poor uniformity or increased expectations. Improving irrigation distribution uniformity, along with optimizing irrigation rates and frequencies by species and region, could have a tremendous impact on water- use worldwide.

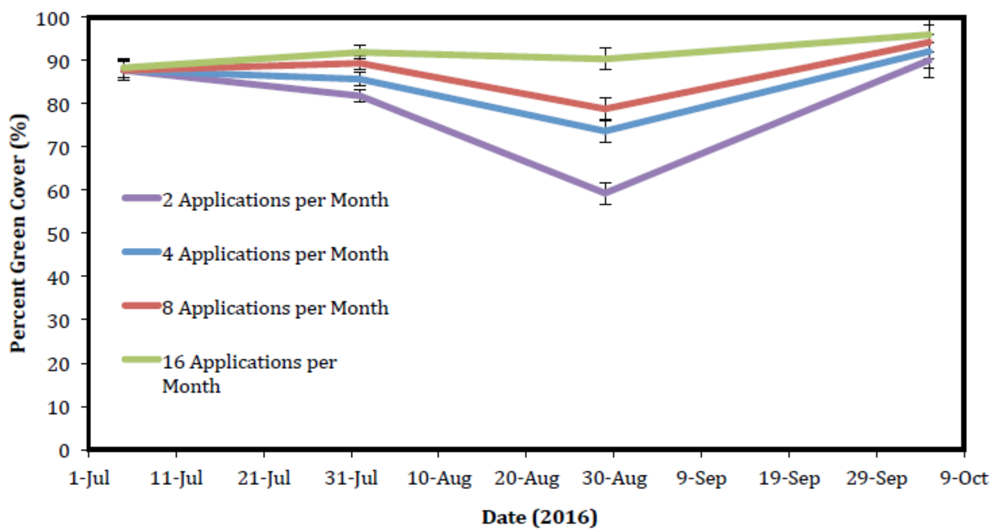

Figure 1: Effect of irrigation frequency on percent green cover over the 2016 summer season in Corvallis, OR. Turfgrass consisted of a perennial ryegrass blend maintained at 5.1 cm. Values are means (n = 20) and 95% confidence intervals estimated using Fisher's projected least significant difference test.

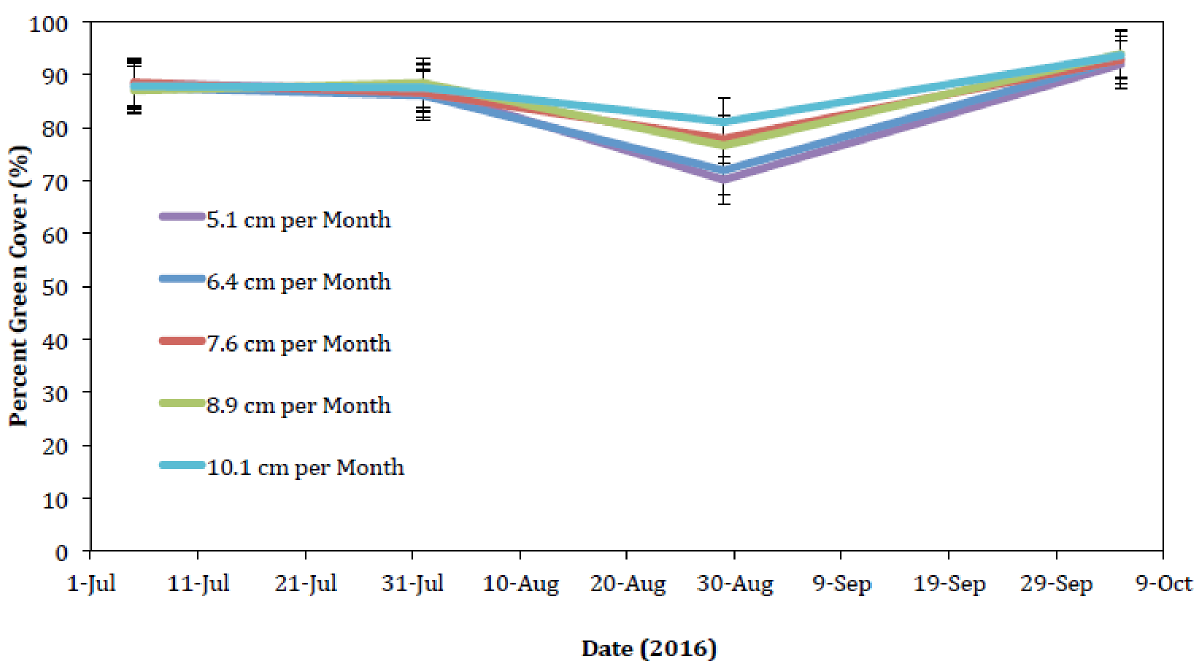

Figure 2: Effect of irrigation intensity on percent green cover over the 2016 summer season in Corvallis, OR. Turfgrass consisted of a perennial ryegrass blend maintained at 5.1 cm. Values are means (n = 16) and 95% confidence intervals estimated using Fisher's projected least significant difference test.

Image 1: The left photo is ¼” applied 4 x per week from July 4 to September 1, 2016, and the right photo is 1” applied once a week from July 4 to September 1, 2016.

Experiment 2: Rainwater Harvesting

The recent trend toward more extreme periods of drought has been a shock to the residents of the Pacific Northwest – many of whom have relied upon heavy water-use in the summer months in order to make a living (i.e. producers of grass seed and sod, berries, or nursery crops), or to maintain their landscapes at high levels (i.e. certain homeowners, recreational facilities, or commercial properties). Furthermore, population growth has reached the point where even an average year of precipitation has proven insufficient for urbanities that had not previously experienced issues with water scarcity. This modern climate scenario has forced people of the Pacific Northwest, and people from all around the world, to rethink their water-use strategies, as the global trend has shifted toward greater sustainability. One potential mitigation strategy for cool-humid regions, is to utilize rainwater-harvesting systems to alleviate freshwater demand. This study documents the construction of two distinct rainwater-harvesting systems (an aboveground cistern and a belowground AQUABLOX™ matrix storage system), and gives insight into their advantages and disadvantages.

There's a large range of options available to people interested in rainwater harvesting. The advantages of the aboveground system were in its simplicity and robustness. Installation took very little effort, and cost was kept to a minimum. The cost of product for the entire 5,000-gal aboveground system was only $3,083. Aside from the fact that the system takes up a decent amount of space and doesn't provide any aesthetic benefits, the only major deterrent to the aboveground system was the stagnant nature of the stored water. Even though the tank had been painted black to eliminate light from entering the water column, there was still a significant layer of slime on the inner walls of the cistern and on the floating outtake. While this had no impact on the function of the tank in the first year of operation, it was decidedly a problem that the water quality decreased (via biomass accumulation) during the storage period.

The subsurface storage system was considerably more expensive than the cistern system, at $12,775 for product and excavation services. The majority of the cost was associated with the Aquablox matrix; however, this is a necessary component for maximizing sub-surface storage capacity. The plastic matrix allowed for the storage of roughly 4,000 gallons of rainwater, while a rock-filled basin of the same size would only hold around 1,000 gallons. Along with the construction cost, another deterrent to the pond-less waterfall system is that electricity is required to power the recirculating waterfall; thus adding to the total cost of the Aquablox system. However, there is no denying the aesthetic benefit of a recirculating waterfall feature, and when considering the fact that the water remains clean throughout the storage period, it may be worth the cost.

Image 2: Pond-less waterfall system (foreground) built next to the cistern system (background) in Corvallis, OR 2016.

Experiment 3: Greywater Irrigation

Freshwater is a limiting resource, and its availability is increasingly a concern. Landscape irrigation, a large portion of the even larger category of outdoor water-use, can be accomplished with water of less-than-potable quality. Greywater makes up a large portion of residentially produced wastewater, thus, its use in landscapes would go a long way toward conserving potable water for other uses. The objective of this study was to impose greywater-irrigated soil conditions – simulating supplemental and continuous disposal applications versus a potable control – on 11 different lawn-height perennial ryegrass cultivars in the Willamette Valley of Oregon, in an effort to evaluate the cultivars and determine whether annual precipitation in the region provides sufficient leaching for safe greywater irrigation.

A two-year field trial was initiated in June 2016 and concluded in September 2017 on native soil at the Lewis Brown Horticulture Farm, Corvallis, OR. Experimental design was a 2 by 11 by 3 strip-plot with three replications. Factors included year, perennial ryegrass cultivars, and greywater irrigation regime. Concentrated overhead spray applications of synthetic greywater (water-softening salt, two laundry detergents, and a chelating agent) were applied twice-weekly as strip-plots over perennial ryegrass plots from June 2016 through September 2017, to represent continuous disposal; from June to September of 2016 and 2017, to represent supplemental irrigation; and compared to a control, which received only potable irrigation.

Interactions between greywater rates and perennial ryegrass cultivars were not observed, suggesting there are a multitude of perennial ryegrass cultivars that serve as viable candidates for greywater-irrigated areas. However, seasonal differences between greywater irrigation regimes were exhibited in the coldest and hottest months of the trial period, suggesting an interaction between greywater irrigation and temperature stress (Figure 3). Seasonal soil analyses showed a buildup of chloride, sodium, boron, and elevated electrical conductivity (EC) with greywater applications.

In Fall 2016, the EC of 0-mo. greywater regime was the lowest, 0.149 dS/m, while the 4-mo. and 12-mo. greywater regimes produced the highest EC, 0.230 and 0.196 dS/m, respectively. In Spring 2017, the 0-mo. and 4-mo. regimes produced the lowest EC values, 0.143 and 0.156 dS/m, respectively, while the 12-mo greywater regime produced the highest EC value, 0.502 dS/m. In Fall 2017, the control produced the lowest EC, 0.149 dS/m, while the 4-mo. and 12-mo. regimes produced the highest EC, 0.249 and 0.251 dS/m, respectively. Rainfall from Fall 2016 to Spring 2017 was sufficient to leach chloride and boron, and drive EC values down in the 4-mo. greywater irrigation regime, although, elevated sodium levels persisted throughout the study. Greywater is a viable irrigation alternative for the cool-humid climates, however, leaching fractions may need to be implemented in the summer months, and continuous disposal sites may see decreased turf quality in the winter months.

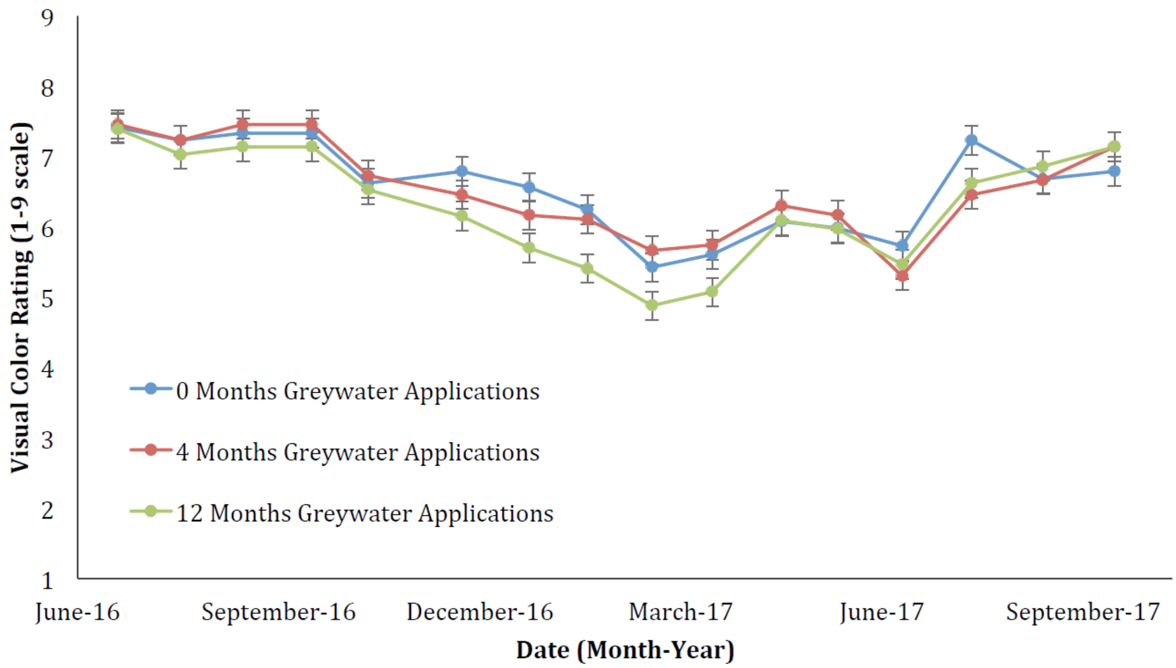

Figure 3: Effect of greywater irrigation regime on visual turfgrass color rating averaged across 11 perennial ryegrass cultivars from the 27th June 2016 to the 1st of September 2017 in Corvallis, OR. Values are means (n = 48) and 95% confidence intervals estimated using Fisher's protected least significant difference test.